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(10) BY F. B. FASSNACHT

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NAVAL SURFACE WEAPONS CENTER

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This report proposes a top level surface ship combat survivability assessment flow chart which is designed to (1) bound the overall problem into clearly delineated subsets, and (2) standardize measures of effectiveness and some terminology. The objective is to provide guidelines for comparing various survivability assessment models relative to each other and relative to the overall survivability problem.

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FOREWORD

The material presented in this report is intended to provide guidelines for comparing various survivability assessment models relative to each other and relative to the overall survivability problem. Suggestions for subdividing the overall problem and measures of effectiveness for each subdivision are also made.

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G. O. MILLER
By direction

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INTRODUCTION

There is a variety of analytical models in existence or development that have application to the question of surface ship combat survivability. This report proposes a top level survivability assessment flow chart which is intended to (1) bound the overall problem into clearly delineated subsets, (2) standardize measures of effectiviness (MOEs) and some terminology and (3) provide a framework for comparing various models and keeping them in perspective relative to the total assessment problem.

DISCUSSION

The proposed top-level surface ship combat survivability assessment structure is diagrammed in Figure 1. It divides the overall survivability assessment problem into three major phases which are clearly delineated by enemy weapon launch and enemy weapon impact. Phase I, Cover and Deception, is concerned with avoiding detection by the enemy or, if detected, preventing the enemy from obtaining the fire control data necessary to launch his weapons. Phase II, Weapon Destruction and Evasion, has to do with preventing these weapons from reaching their intended target either by destroying them or by causing them to miss. Phase III, Damage Tolerant Design/Damage Control and Repair, deals with (a) the ability of our ship to absorb the effects of the weapon with a minimum loss in capability (i.e., graceful degradation) and (b) the ability to restore those ship's capabilities that were lost because of the weapon impact.

These three phases may be analyzed independently using scenarios tailored to each phase or concurrently using the same scenario throughout. In the latter case, the output of Phase III must be fed back into each of the analysis blocks to reflect any damage induced reduction and/or loss of own ships' capabilities as the overall analysis proceeds in time. These feed-back paths are not shown on Figure 1.

Regardless of how the overall analysis is done, each phase has its own output in the form of the cost for installing a change on the ship versus the change in MOE relative to that achieved with the unaltered ship. However, there is no analytical model postulated for combining the individual outputs into one overall output; no one model would have the credibility necessary to have wide acceptance at command levels. In justification of this position consider two points which drive the MOEs for Phases I and II to unity. First - in carrying out its primary mission to defeat the enemy, the Navy must sooner or later engage him at which time the probability of an enemy attack will approach one. Second - there will be occassions when because of lack of prepardiness, equipment outages or overwhelming enemy forces, our ship's defensive capabilities will be unable to cope and the probability of damage will again approach one. Thus, the final decision of where to spend the available funds for improving the survivability of a given ship is best left to those who will live with the decision, ** and *** line officers. The analyst's job is to present the alternatives for each phase clearly and completely.

What about our ships's offensive capabilities? Why not defeat the enemy's ships, planes and submarines before they have a chance to launch any weapons? There is no question but that our ship's offensive capabilities will affect it's combat survivability. These capabilities are not included here on the assumption that the purpose of a combat survivability assessment is to aid in defining the defensive capabilities our ships should have. A ship's

offensive capabilities would be defined by mission considerations, not survivability considerations.

PHASE I - Cover and Deception

This phase covers the time-frame prior to launching of weapons against our own ship or task group. As stated earlier the concern is avoiding detection or, if detected, preventing the enemy from obtaining the fire control data needed to launch his weapons.

There are two approaches to defining scenarios for this phase. One is the war gaming approach where a tactical situation and force composition are specified, and individual units are tracked through the problem with all possible interactions between units analyzed. The other is to make a parametic analysis of sensitivity to each of the enemy's capabilities. Each approach has its place in analysizing combat survivability. Factors which should be considered in defining a scenario are:

a. Independent or Task Group operations. Independent operations are easily defined; it's one ship against the world. Task group operations bring added variables to the analysis. Shall the MOE's be for the task group as a whole, for each ship in the group, or only for the high-value ships in the group. Input options involve not only individual ship capability changes but also changes in the makeup and tactics of the task group.

b. Threat composition. The scenario should consider all forces which the enemy can bring to bear for the postulated situation. Possibilities are satellites, on-shore and off-shore systems, submarines, surface ships and aircraft. Also it should be assumed that these various platforms can exchange data and operate in concert as well as individually.

c. Readiness condition. Our ship(s) will not always be at Condition I (battle readiness). They could also be at Condition III (wartime cruising readiness) or Condition IV (peacetime cruising readiness). For defensive scenarios, Condition III is more likely during Phase I. For a ship at Conditon IV a Phase I analysis is moot and it can be assumed that the enemy will launch his weapons.

The inputs for this phase are options changing our ship's or task group's capability to evade and confuse the enemy. For an individual ship such options include signature reduction (acoustic, magnetic, visual, RF, IR), EMCON procedures, off-board decoys, false signatures for deception, and jamming of fire control sensors. For a task group additional confusion options are possible by time sharing necessary sensor emissions among the ships in the task group.

The MOE for Phase I is the change in probability of being attacked resulting from a given input option. Being attacked is here defined as the enemy launching a weapon having a non-zero probability of affecting our ship or task group.

The detection analysis model has to determine, for a given scenario, whether or not the enemy can localize and classify our ship or task force accurately enough for him to launch his weapons. It should also supply inputs such as time and location of weapon launch for use in Phase II analysis.

Decision making for this phase is based on comparing the cost for a given option with the change in probability of attack resulting with that option against the same for other options. Costs should include indirect costs such as increased manning and maintenance requirements, if any, as well as direct hardware procurement and installation costs. Comparisions should be made

for a range of meaningful scenarios before a final ranking of options is made.

PHASE II - Weapon Destruction and Evasion

This phase covers the time-frame from weapon launch to weapon impact. The concern during this phase is to either destroy or evade the enemy weapons and thereby prevent damage to our own ship or task force.

The scenario for this phase can either be a continuation of a war gaming type scenario from Phase I or the parametic analysis type where sensitivity to each of the enemy weapons is considered. Types of weapons to be considered are: mines, torpedos, projectiles, bombs and missiles. These weapons can be either submarine, surface ship, aircraft or land launched. In addition to weapons, the enemy's jamming and deception capabilities should also be included in the scenario. As in Phase I the scenarios should also consider independent and task group operations, and readiness conditions. One scenario which should not be overlooked is transiting through a minefield.

The input is primarily options in combat systems effecting our ships capability to destroy (hard kill) or evade (soft kill) incoming weapons. However, options in maneuverability which could impact our ship's soft kill capability should not be overlooked. Other considerations are doctrines for use of the combat system and task group composition and tactics.

The MOE is the change in probability of being damaged by enemy action resulting from a given input option. Damage is here defined as any equipment or personnel casuality which has a potential for reducing the mission readiness of our own ship or task group. For task group scenarios the definition could be adjusted to cover only high-value ships.

The engagement analysis model has to determine, for a given scenario, whether or not any of the enemy weapons would overcome our ships's or task group's hard and soft kill capabilities and impact or burst at a location from which the warhead could cause damage. The analysis should allow for secondary damage mechanisms such as fragments from a missile "killed" by CIWS and underwater shock from near splash-in of an evaded missile. It should also supply inputs such as location and orientation at time of burst for use in the Phase III analysis.

Decision making for Phase II is based on comparing the cost for a given option with the change in probability of damage to our own ship or task group resulting with that option against the same for other options. Other comments made regarding Phase I decision making also apply here.

PHASE III - Damage Tolerant Design/Damage Control and Repair

This phase covers the time-frame following weapon impact. The concern is to minimize the immediate and time-varing cumulative effects of a weapon impact on our own ship's structure, equipment and personnel. Phase III divides into two subphases: IIIA Covering the time prior to initiation of damage control and repair procedures by the crew, and IIIB covering the time after initiation of damage control and repair procedures by the crew.

The scenario for Phase III can be a continuation of a Phase II scenario or a parametric analysis type beginning with the location and orientation of a warhead when it detonates. The types of warhead effects to be considered are: blast, fragmentation, shaped charge, underwater shock, chemical, biological, radiation and electromagnetic pulse. All three readiness conditions - I, III and IV - should be considered. Phase III scenarios will generally focus on a single ship, but task groups can be modeled by generating a task group MOE from the individual ship MOEs.

Inputs for this phase consist of options in personnel and equipment. The personnel options involve crew composition and their location throughout the ship. Equipment options involve ship layout, protection for equipment and personnel, equipment interconnections and redundances, automated and manual damage limiting or control features, damage repair facilities and spare parts.

The MOE for Phase III is the change in mission area readiness versus time resulting from a given input option. This is not a probability of kill. It is a measure of how well a ship can perform its designated missions relative to its designed performance of those missions. Mission area required operational capabilities and readiness rating criteria are defined in the 3501 series of OPNAV instructions and amplified in various TYCOM instructions. Mission area readiness has been chosen as part of the MOE for Phase III because (1) it puts emphasis on things the Fleet considers important, (2) assessment results will be in terms meaningful to senior naval personnel and (3) it permits direct comparison of diverse input options, such as additional guns versus a larger damage control group. The time portion of the MOE is necessary because the effect of a given casuality can become progressively better or worse with time. The importance of time is a function of the scenario. Some scenarios may take minutes (i.e. ASMD), others may take hours. What ultimately counts is the ships's mission readiness at the time it must perform.

Because this MOE is relatively unused in the analysis community, the flow chart details the steps for generating it. The NAVFORSTAT Readiness Rating Logic comes from TYCOM instructions. It is in the form of decision trees for each mission area. These individual trees, one each for personnel, equipment, training and supplies, determine readiness on a scale from M1 (fully capable) to M4 (not ready). For survivability analysis, normally only the

personnel and equipment trees are necessary. For analysis community use, these decision trees should be amplified by converting their inputs from generalized statements to definitive quantities specific to the ship class being analyzed. The Total Ship Functional Interaction Logic is derived from ship manuals and drawings. It details all of the functional interactions and connections between elements of the various ship systems including any time dependencies of these interactions. This logic defines the cascading effects of initial casualities derived in the Equipment Damage Analysis. The major point in developing this logic is to consider the ship as a whole (the Captain's point of view) when assessing damage effects and not consider each ship system or warfare area as an independent entity. Deactiviation diagrams are a form of functional interaction logic but usually do not include time factors or degraded performance levels.

The analysis for Phase IIIA consists of two parts: Equipment Damage Analysis and Personnel Injury Analysis. Some models may combine these parts but they are shown separately here to emphasize that both equipment and personnel must be considered when analyzing the affect of combat damage on mission readiness. The output from these analyses is the specific equipment (including the hull), interconnections and personnel effected by a given weapon impact and the degree to which they are affected. This output should be a function of time and in addition to primary warhead effects also include secondary effects such as explosions, fire, smoke and flooding.

The analysis for Phase IIIB is also in two parts: Equipment Repair Analysis and Personnel Recovery Analysis. The Equipment Repair Analysis must consider all alternatives for restoring ship capabilities which are still available after the degree of damage is stabilized and whether or not knowledgeable personnel are available to affect each specific repair. Its output is the

time-varing status of specific equipments (including the hull). The Personnel Recovery Analysis has two questions to answer: as a function of time how are the ship's operating positions remanned, and also as a function of time which damage control personnel are available to begin repair procedures. Both of these depend on the type of injuries and specific personnel injured.

Finally, decision making for Phase III is based on comparing the cost for a given option with the time-variation in mission readiness resulting with that option against the same for other options. Costs for personnel options should include any ship alterations needed to accomodate added crew. Costs for configuration options should include both procurement and installation costs as well as additional maintenance costs, if any. These comparisions should be made for a range of meaningful scenarios before a final ranking of options is made.

SUMMARY

This report has proposed a top level surface ship survivability assessment flow chart intended to put such assessments in an operational context and highlight the major factors to be considered in evaluating the completeness of any particuliar analytical model.

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Major points ~~which have been made~~ are:

(1) The overall assessment divides into three distinct phases, Cover and Deception, Weapon Destruction and Evasion, and Damage Tolerant Design/Damage Control and Repair, delineated by two unambiguous events, weapon launch and weapon impact.

(2) The measures of effectiveness for each phase are all relative measures, <u>not</u> absolutes. — , p.14

(3) Specific analysis models must consider personnel as well as equipment; An unmanned ship is useless.

(4) The proper MOE for Phase III is time-variation in mission readiness, not probability of kill. Using mission readiness puts emphasis on what the Fleet considers important and analysis results in terms meaningful to command levels.

(5) Because of the many imponderables involved, combining the results from each phase into an overall conclusion is a human's job. No analytical model would have enough creditability to justify building it.

Two additional points worth making are:

(6) A standard set of command approved scenarios is needed which cover the full range of operations the Fleet considers meaningful in terms of combat survivability.

(7) Analytical models are a useful and important engineering tool. However, they must be kept in proper perspective relative to the real world. Once a person starts taking a model literally he or she is lost.

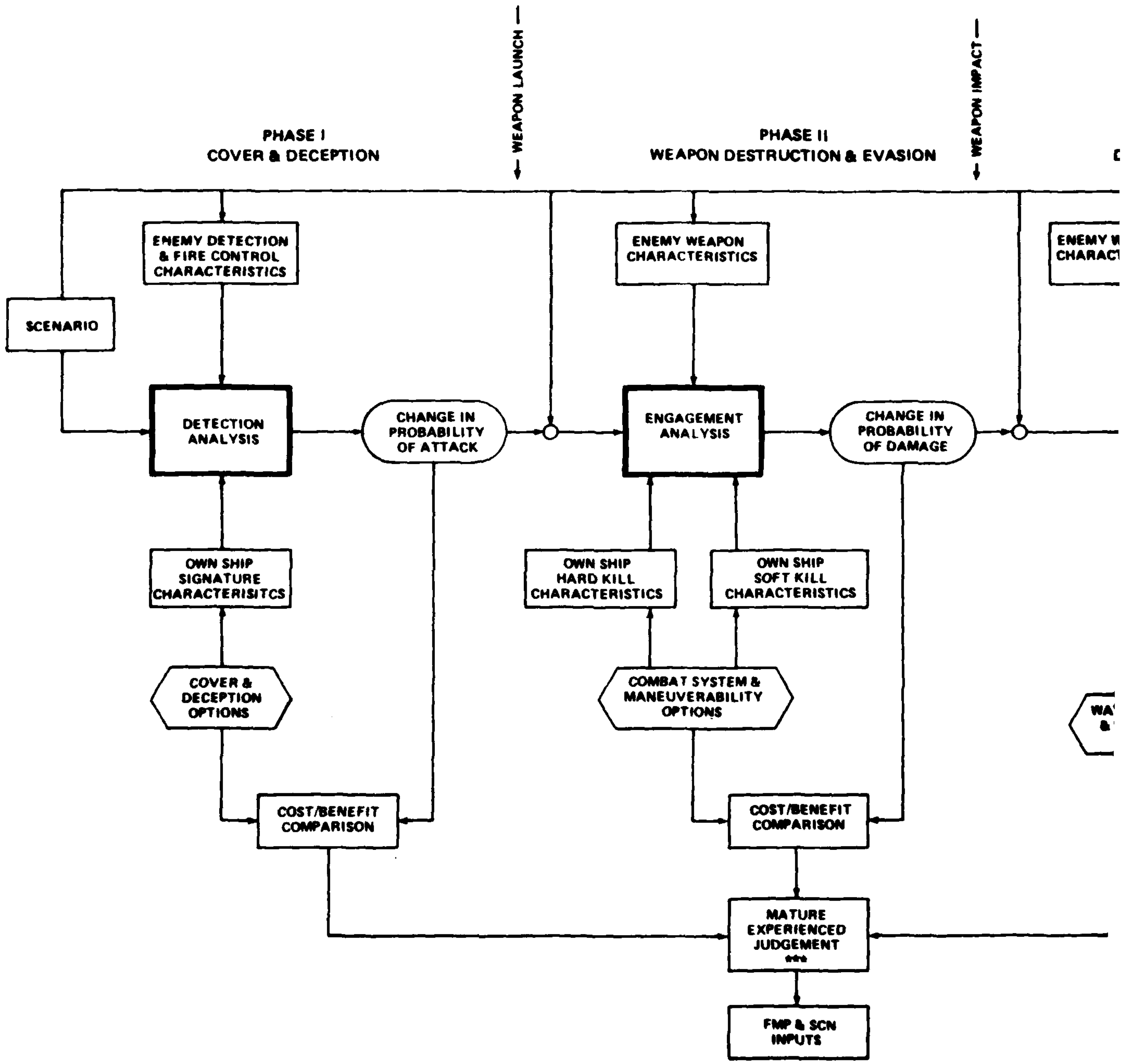

FIGURE 1 SURFACE SHIP C

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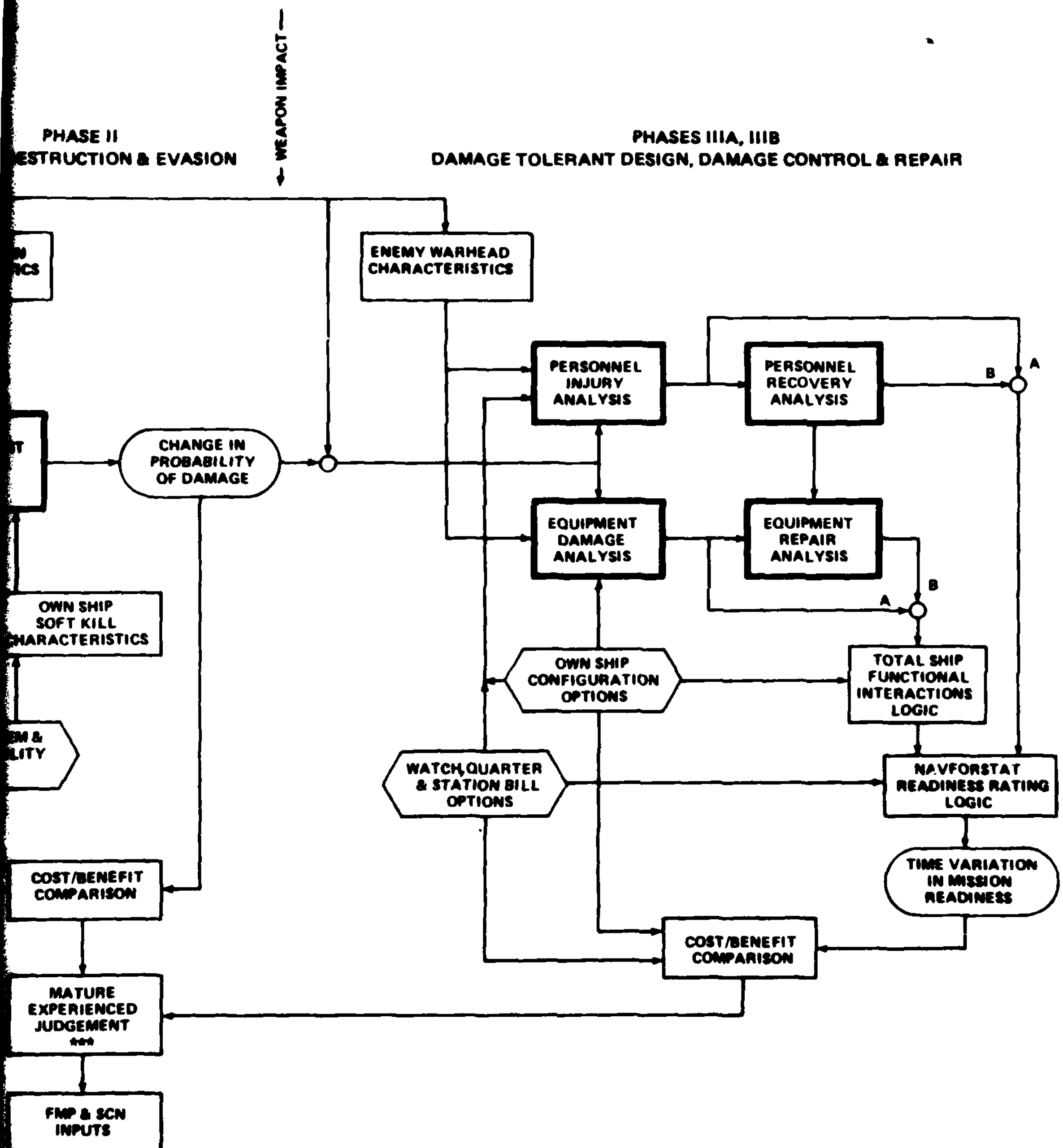

FIGURE 1 SURFACE SHIP COMBAT SURVIVABILITY ASSESSMENT FLOW CHART

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